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Smart Data Selection (SDS) Brief

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"The dominant inherent nature to TM in DoD testing is sampled time-history data from an ultimately analog world, (which) is not going to change drastically regardless of how data is transmitted to ground. A factor that could change that fact most is the degree to which answers instead of data are obtained on board the test vehicle" iNET Concept of Operations, v. 2007.1

SDS seeks to change this inherent nature of telemetry in DoD testing by:
Developing an on-board capability to monitor and analyze test data in order to reduce the amount of data sent to the ground
Employing bandwidth efficient algorithms to reduce bandwidth requirements
Developing the capability to notify operators when data demonstrate abnormal behavior

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Shannon Wigent & Dr. Andrea Mazzario

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AFTC

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Outline

- Project Description
- SDS ConOps
- System Description
- Bandwidth Efficient Algorithm
- PCM Compression Enhancement
- Benefits to T&E

Project Description

"The dominant inherent nature to TM in DoD testing is sampled time-history data from an ultimately analog world, (which) is not going to change drastically regardless of how data is transmitted to ground. A factor that could change that fact most is the degree to which answers instead of data are obtained on board the test vehicle" iNET Concept of Operations, v. 2007.1

- SDS seeks to change this inherent nature of telemetry in DoD testing by:
  - Developing an on-board capability to monitor and analyze test data in order to reduce the amount of data sent to the ground
  - Employing bandwidth efficient algorithms to reduce bandwidth requirements
  - Developing the capability to notify operators when data demonstrate abnormal behavior

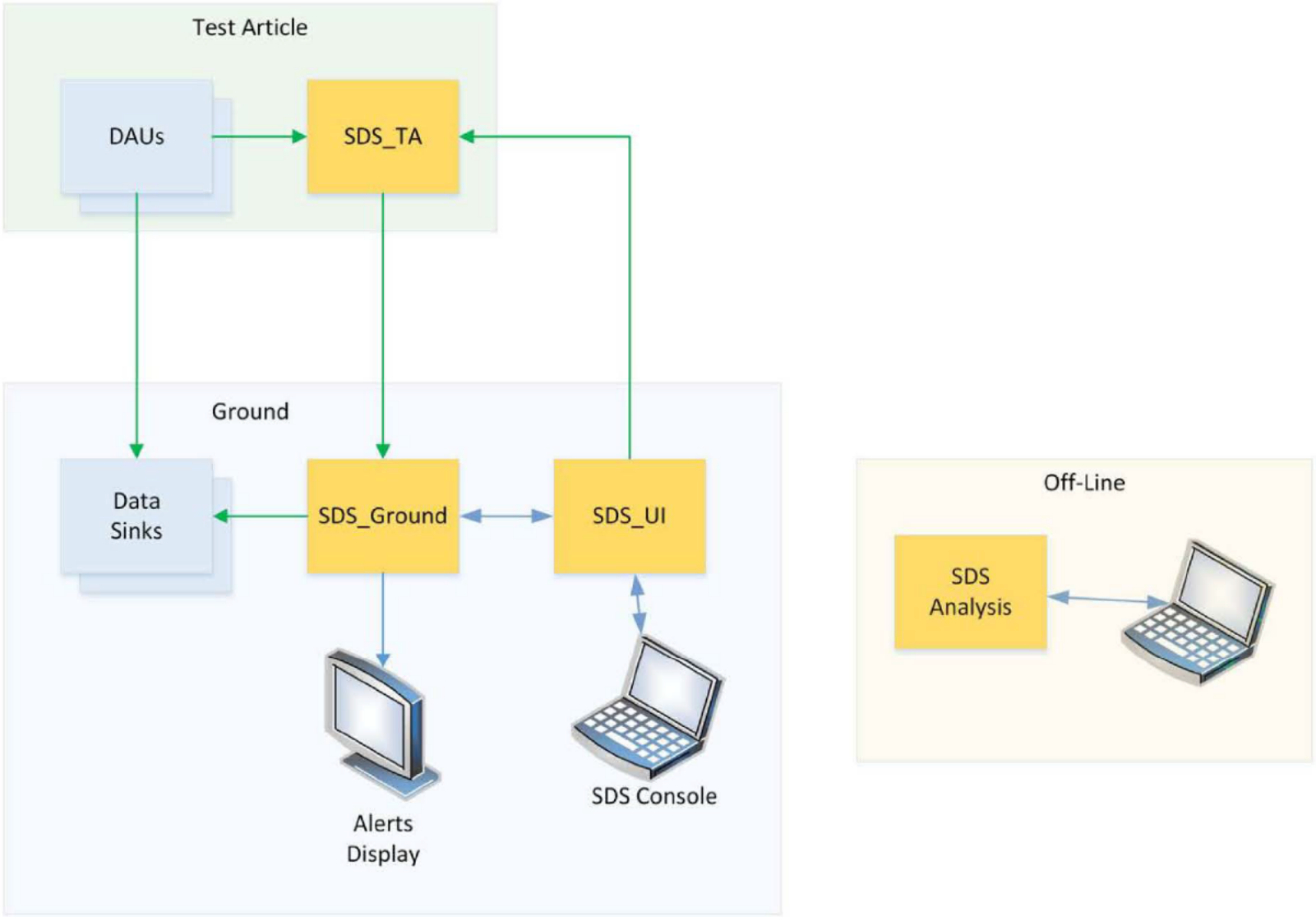
Results in Significant Savings in Spectrum and Increased Operator Awareness

SDS ConOps

The SDS system:

- Analyzes pre-recorded data to identify behavioral trends
- Applies user-defined behavioral criteria
- Subscribes to all on-board parameters
- Determines what live data is of interest for real-time observation and analysis
- Applies bandwidth efficient algorithms to select measurements
- Generates specific messages to be sent to ground
- Provides alerts for data that demonstrate abnormal behavior
- Supports user feedback in response to alerts

System Description



Bandwidth Efficient Algorithms

- SDS applies extrapolation algorithms to “Normal” data
  - Allows for TA transmission of extrapolation parameters rather than individual measurement values
  - Ground calculates and publishes with required frequency
- TA monitors error between extrapolation values and actual measurements
- If error threshold exceeded, new parameters are calculated and applied

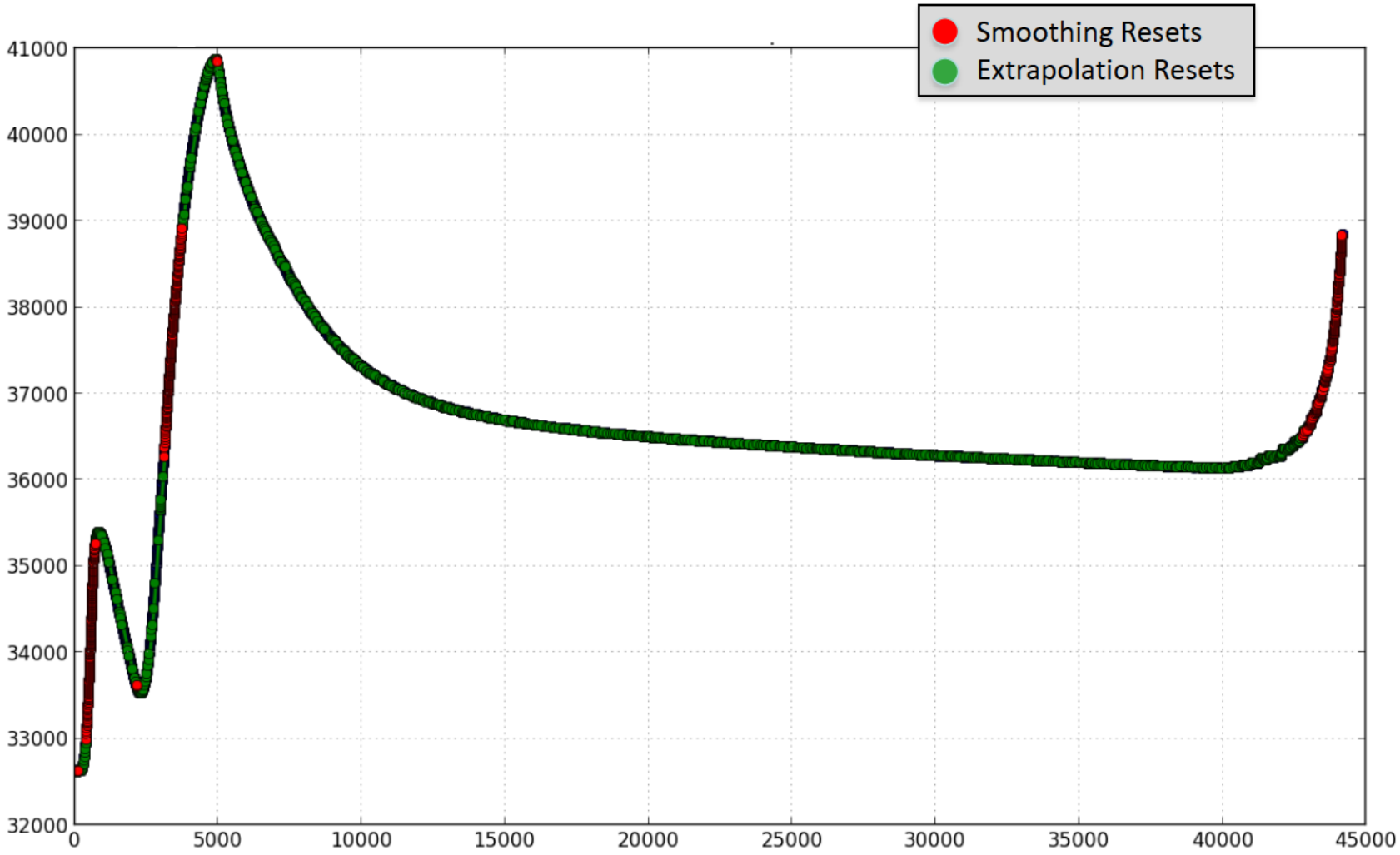
Bandwidth Savings

- Representative test results:
  - ~45,000 measurements at 98.04 Hz
- **Very small error threshold:**
  - **Error <= 0.01%**
  - **SDS requires less than 7% of original bandwidth**
- **Small error threshold:**
  - **Error <= 0.02%**
  - **SDS requires less than 3% of original bandwidth**

Bandwidth Efficient Algorithms

- Exponential Smoothing
  - Single Exponential Smoothing
    - sv[i] = a*m[i] + (1- a)*sv[i-1]
    - Extrapolation: ev[i+n] = sv[i]
  - Double Exponential Smoothing
    - sv[i] = a*m[i] + (1 - a)*(sv[i-1] + t[i-1])
    - t[i] = b * (sv[i] - sv[i-1]) + (1 – b)*t[i-1]
    - Extrapolation: ev[i+n] = sv[i] + n*t[i]

Thermocouple Example

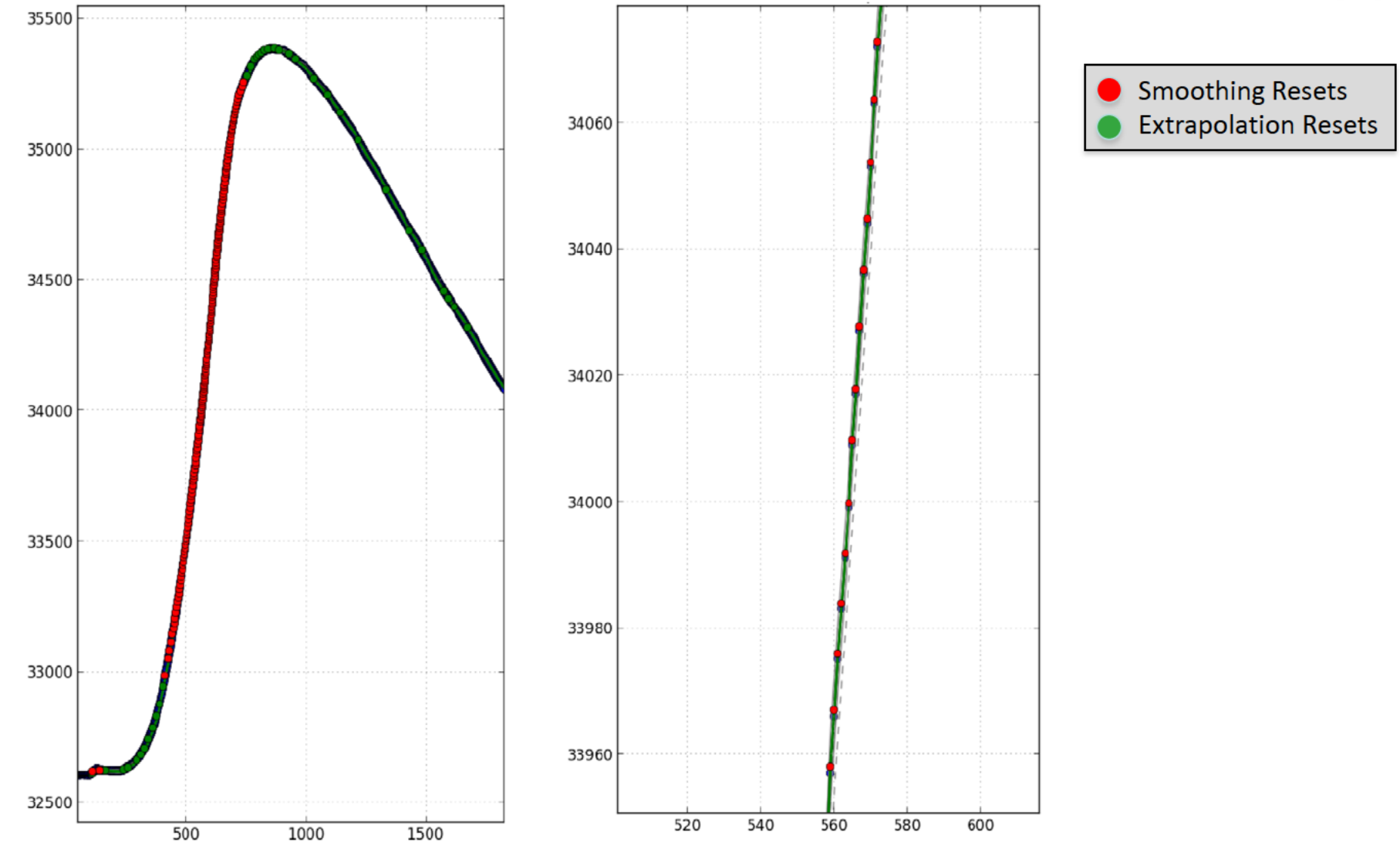


~45000 measurements @ 98.04 Hz

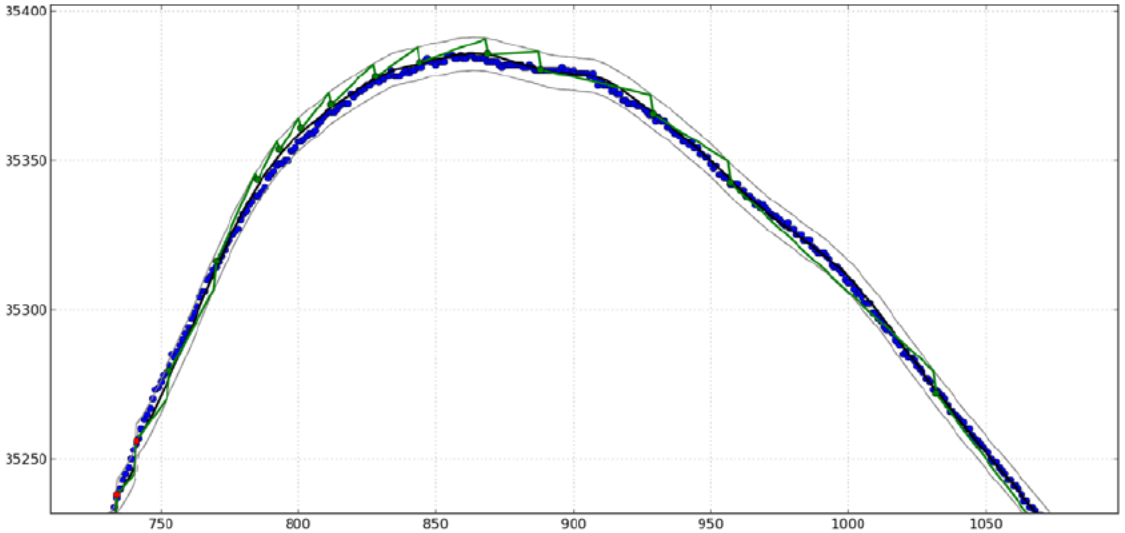
Bandwidth Savings

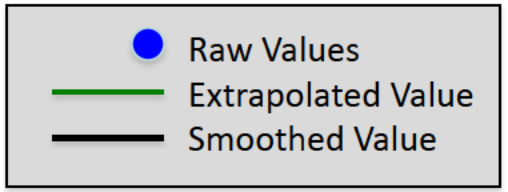
- 44091 Measurements
- Measurement Size = 2 bytes
- Error threshold of 0.01%
- 1001 EBE Resets
  - Transmission Cost =~3 Measurements
- Extrapolated Data = 1001 x 2 x 3 = 6006 bytes
- Raw Measurements = 44091 x 2 = 88192 bytes
- **SDS uses less than 7% of bandwidth required to send raw data**

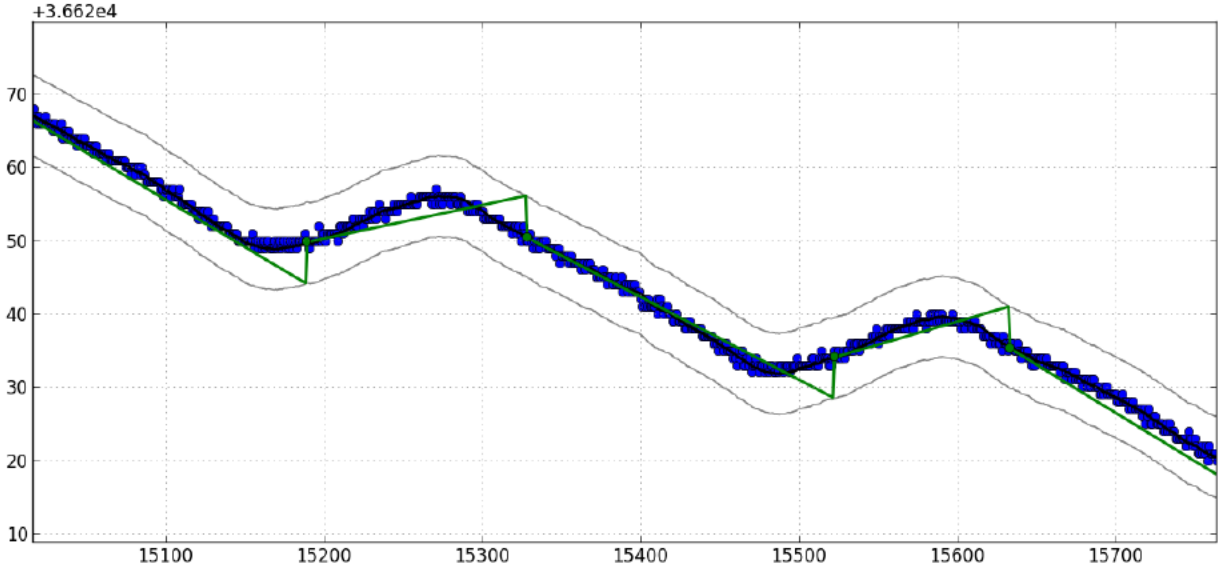
Enlarged View



Enlarged View







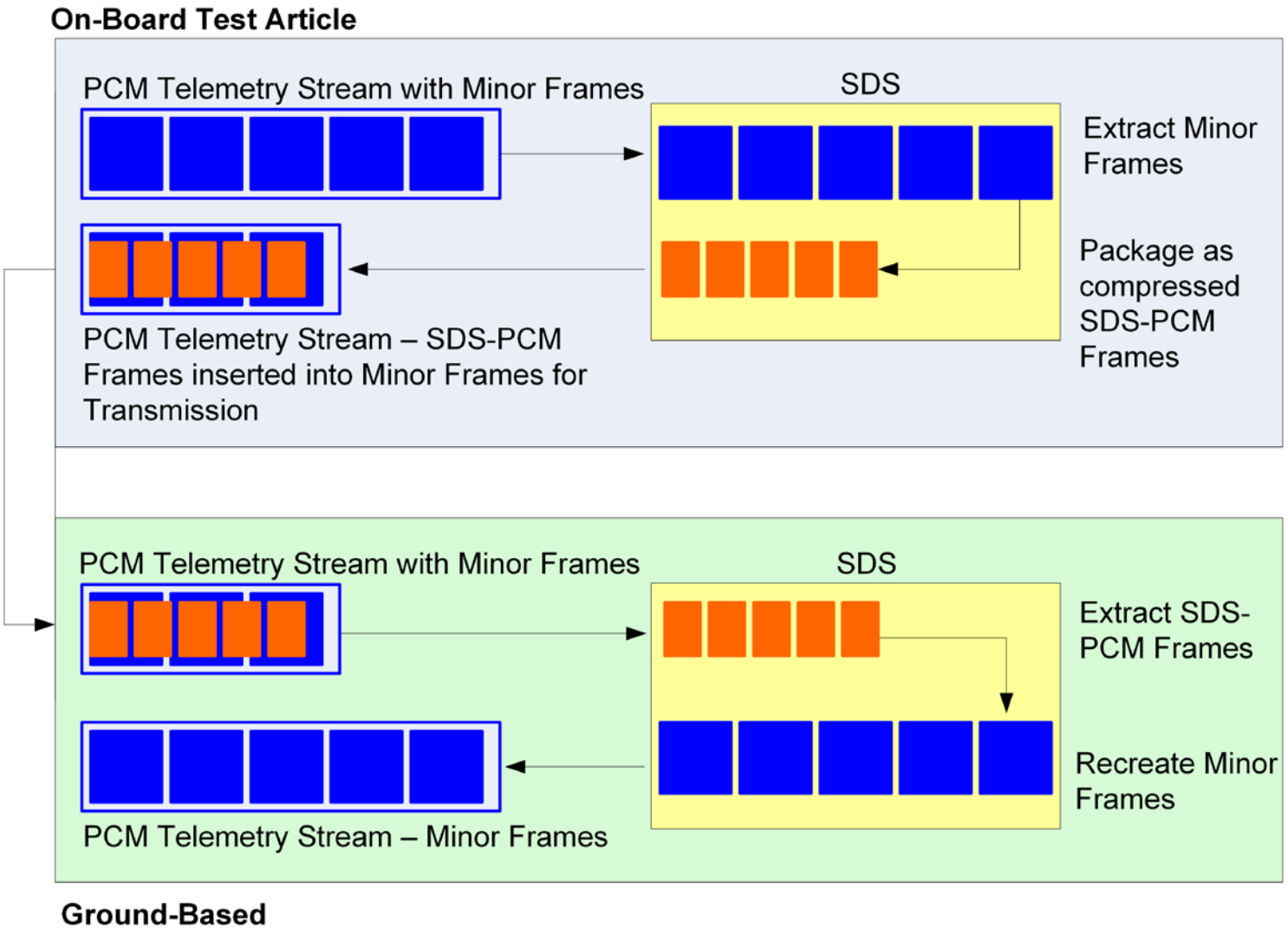
Introduction of PCM Compression

- Utilize existing SDS framework to apply compression to PCM
- Provide PCM compression within TmNS messages
- Apply lossless data compression algorithms in conjunction with error correction for significant bandwidth savings

Benefits of Compression

- Potential to yield a 70% increase in bandwidth utilization
  - Provides availability to great volume of test data
  - Provides ability to support increased number of test articles concurrently
- Utilization of telemetry data characteristics improves upon compression rates resulting application of standard lossless compression

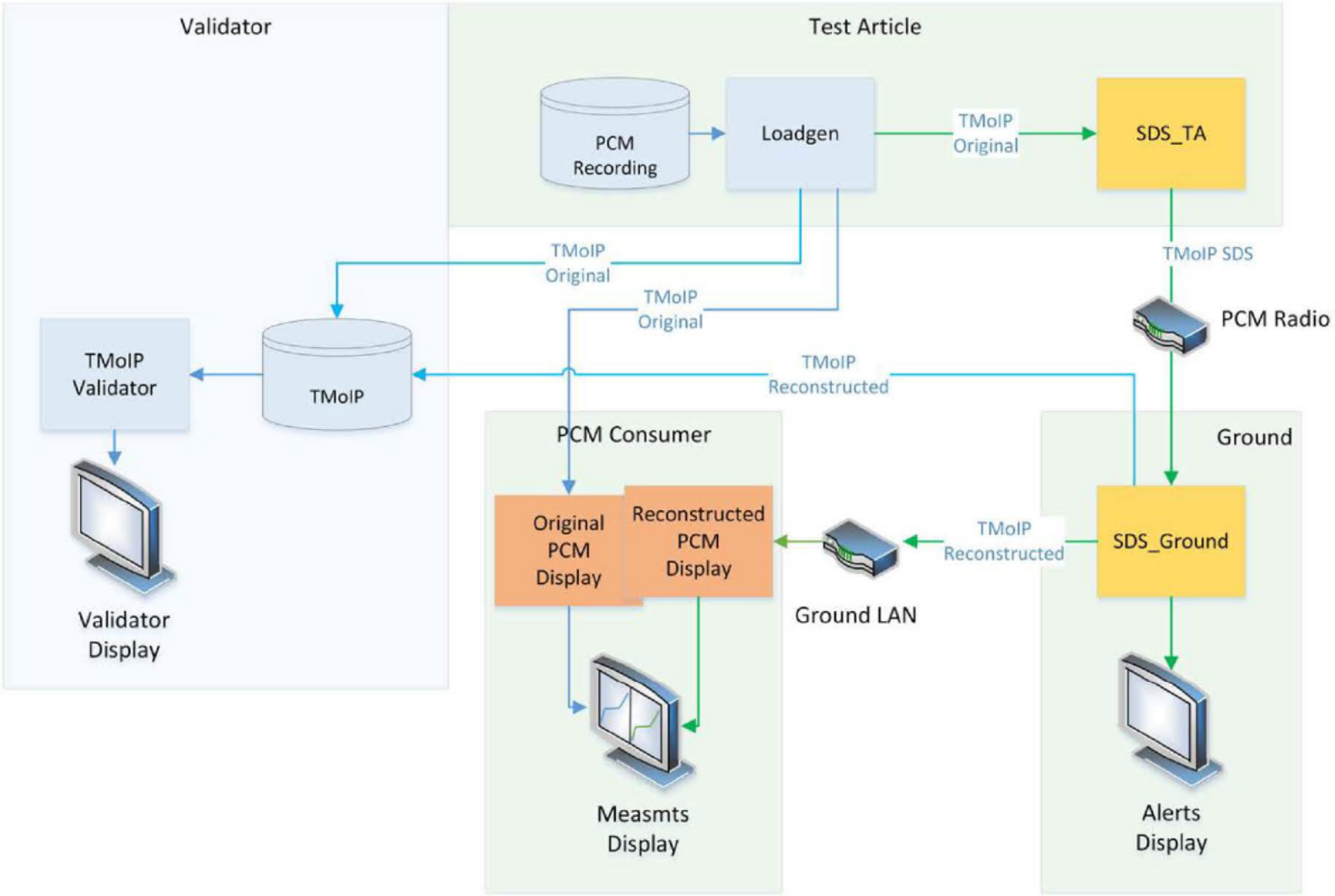
Introduction of PCM Compression



PCM Enhancement

- SDS current implementation is based on TmNS message format
  - Test Article and Ground modules to be updated to process PCM minor frames embedded in TmNS messages
- New capability added to process PCM in traditional PCM environment

PCM Demo


Validator
Test Article
PCM Recording
Loadgen
TMoIP Original
SDS_TA
TMoIP Original
TMoIP Original
TMoIP SDS
PCM Radio
TMoIP Validator
TMoIP
TMoIP Reconstructed
PCM Consumer
Ground
Original PCM Display
Reconstructed PCM Display
TMoIP Reconstructed
SDS_Ground
Ground LAN
Validator Display
Measmts Display
Alerts Display

Benefits to T&E

- Bandwidth Savings/Increased Spectrum Efficiency
  - For measurements that demonstrate a normal behavior, transmit to the ground only a representation rather than the entire data set
- Simplified Pre-Test Configuration of Test Article Commutator
  - Analysis of pre-recorded test data allows for determination of expected behaviors
  - Allows for automatic configuration of transmission rates
- Enhanced Operator Awareness of Test Conditions
  - Automatic operator notification when data values outside of normal range
  - Allows operators to focus on situations requiring immediate attention

QUESTIONS?